Additional Gabions Input

Frequently, there is a need for gabions beyond the number calculated by the program. For example, you may want to increase the number of each gabion size by 5% to account for unforeseen conditions or for small additions to the design. After the program determines the required number of gabions of each size, you can specify additional gabions of each size to be added to the total.

Gabion Lining Thickness

The gabion thickness required for channel protection is based upon gabion studies performed by Simons and Li, Associates (Simons, et al, 1984). The program determines the thickness according to the water velocity. If the water velocity is less than 15 feet (4.6 meters) per second, the gabion thickness is 1 foot (0.3 meter). If the velocity is greater than 15 feet (4.6 meters) per second, the gabion thickness is 1.5 feet (0.5 meter). If the water velocity is less than 3 feet (1 meter) per second, the program will state that gabions are not needed and will not let you continue. If the computed water velocity is greater than 20 feet (6.1 meters) per second, the program will give a warning that you are reaching the limits of gabion protection for such high velocities. The program will not allow a water velocity greater than 25 feet (7.6 meters) per second and will give you a message stating that the velocity is too high for gabions.

Filters

The flow of water over the gabions causes local flow fluctuations, resulting in positive and negative water pressures. This action can cause a "pumping" action which can extract fine material under the gabions and pull it through the void spaces between the gabion rocks. This will cause scour beneath gabions, cause the gabions to stretch at the connection and eventually tear apart as the gabions fall into the scour hole. To prevent this, filter linings are often placed beneath the gabions. These linings can be of granular material such as a mixture of gravel and sand, or more typically, they are made of fabric of a specific thickness and strength, depending on the hydraulic and local soil conditions. Since filters depend on such variable conditions, the program does not design the filter but points out that such filters should be considered in the design.

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Water Surface Profile Computations–How Many Sections Do I Need?

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Abstract

One-dimensional streamflow models, including standard-step models, require a sufficient number of cross sections to satisfy two needs. First, a sufficient number of cross sections must be provided so that the model of each stream reach, as represented by the terminal cross sections, preserves the geometric and hydraulic properties of the prototype. Second, a sufficient number of cross sections must be provided to allow the model to correctly estimate the solution of the governing equations in discrete space. Two test cases were developed and solved to demonstrate these concepts. The first case required two cross sections to describe the geometry and 17 computational cross sections. The second case required three cross sections to describe the geometry and 9 computational cross sections. Without the addition of computational cross sections, the water-surface profiles had errors of about 0.4 feet and 2 feet, respectively.

Water Surface Profile Computations

The standard-step method for gradually-varied flow is usually used to computed steady-state water-surface profiles. Computer programs, such as HEC-2 (U.S. Army Corps of Engineers, 1990) and WSPRO (Shearman, 1990), use an energy equation written over a computational reach in terms of the water-surface elevation,

$$Y_2 + \frac{\alpha_2 V_2^2}{2g} = Y_1 + \frac{\alpha_1 V_1^2}{2g} + h_e \quad (1)$$

where:

Y_1, Y_2 = water surface elevations,
α_1, α_2 = velocity coefficients,
g = gravitational constant, and
h_e = energy loss.

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The energy loss, h_e, is a function of both friction (boundary shear) and minor losses (resulting from expansion and contraction of the channel cross section). In HEC-2, h_e is usually expressed

$$h_e = L\overline{S}_f + C\left|\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right| \tag{2}$$

where:

L = reach length,

$\overline{S}_f$ = mean reach friction slope, and

C = expansion or contraction loss coefficient.

Computation of the water-surface profile proceeds by iterating the water-surface elevation, Y, for solution of equation 1 using successive approximation. The energy loss term, h_e (equation 2), is evaluated at each iteration using the current value of water-surface elevation. Iterations cease when some closure criterion is achieved (or no solution is found) and the solution proceeds to the next upstream or downstream reach until the complete water-surface profile is computed.

Estimating Friction Losses

Four methods for computation of friction losses (the first term of equation 2) are presented in the HEC-2 user's manual. The Corps recommends use of the average conveyance equation for computation of mean friction slope. However, the U.S. Geological Survey (Shearman, et al., 1986) uses the geometric mean friction slope equation. In fact, the HEC-2 user's manual presents two additional methods for estimating mean friction slope. Reed and Wolfkill (1976) investigated seven methods for estimation of mean friction slope.

If minor losses are ignored, then $h_e = \overline{S}_f L$, which is a numerical integral of the friction slope, S_f, over the computational reach. Therefore, methods for estimating mean friction slope are weighting functions for numerically computing the integral of the friction slope. That is,

$$\begin{aligned} h_e &= \int_L S_f dx \\ &= \overline{S}_f L. \end{aligned} \tag{3}$$

The choice of method for estimating mean friction slope is tantamount to choice of a numerical quadrature for computing the integral. Therefore, all viable methods for estimating mean friction slope should, as the reach length decreases, result in the same water surface profile. Because computation of energy losses through each reach depends on a numerical approximation, the integral of friction slope, then the solution may display dependence on the computational step size. Consequently, lack of convergence of the solution may cause errors and convergence testing is required.

Convergence of Numerical Models

Thompson (1992) described convergence and convergence testing for hydrodynamic models. Essentially, convergence is the state achieved by a numerical model when reduction in the size of the computational step results in no refinement of the solution. If the model is consistent, then differences between the convergent numerical solution and the analytic solution (if one could be computed) would be attributable only to model error.

How Many Cross Sections?

First, the modeler must provide enough physical measurements to describe the geometry and hydraulics of the river reach. That is, enough data must be taken in the field to enable the modeler to construct a correct mathematical representation of the physical entity being modeled. Second, the modeler must provide enough computational cross sections to ensure that model output is insensitive to the distance between sections. That is, a sufficient number of computational points must be included so that the energy loss, h_e, is properly computed by the approximate integration in equation 2, regardless of the method used to estimate mean friction slope.

Frequently, application of these two criteria requires more computational sections than field sections. If this is the case, then the modeler (or the model) must interpolate computational sections from field sections if the model is to be convergent.

Proof

Two simple test cases were constructed to illustrate these concepts. The first case is a rapidly expanding channel reach 100 feet long and rectangular in cross section. The upstream bottom width is 100 feet and the downstream bottom width is 800 feet. Mannings n is 0.03 and the channel bottom is horizontal in the longitudinal direction. The flow rate is 4000 cubic feet per second and depth at the downstream boundary is 7.2 feet.

The water-surface profile through the reach was computed with HEC-2. Convergence was tested with multiple HEC-2 runs, with subsequent runs distinguished by having twice as many computational cross sections. Water-surface profiles from runs with a computational distance of 100 feet and 6.25 feet are shown on Figure 1. Because the model reach is short (only 100 feet), the energy loss from friction is negligible (less than 0.01 foot), and the solution demonstrates the trade-off between pressure energy and kinetic energy as the cross section changes. The maximum difference between the two profiles is about 0.4 foot, which is a significant difference when considering that many regulations allow a maximum increase in water-surface elevation of 0.5 foot for encroachment on natural floodplains. Furthermore, this problem demonstrates that the water-surface profile is not resolved (that is, the model has not converged) until the computational distance is reduced to about 6.25 feet. However, the two end sections clearly are sufficient to represent the geometric and hydraulic properties of this channel.

The second case is a channel with a rectangular cross section which begins with a bottom width of 100 feet at the downstream end of the reach, expands linearly to 500 feet at a distance of 5,000 feet upstream, then contracts to 100 feet at a distance of 10,000 feet upstream. Mannings n is 0.03 and the longitudinal slope is 0.0005. The flow rate is 2000 cubic feet per second. Depth at the downstream boundary is 5.93 feet.

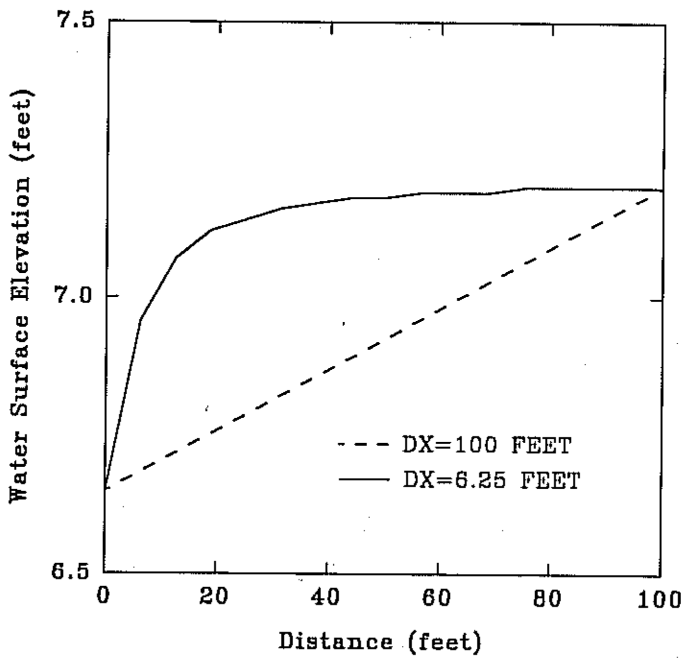

Figure 1: Water-surface profile for expanding reach.

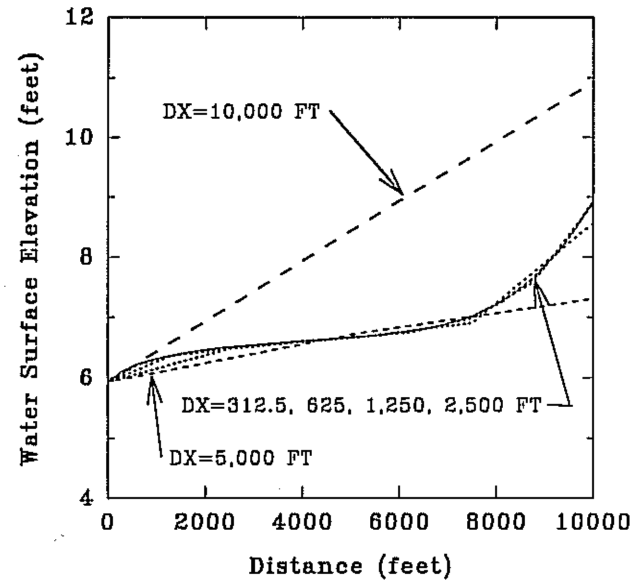

Figure 2: Water-surface profile for expanding and contracting reach.

As before, the water-surface profile through the reach was computed using HEC-2. Convergence was tested with multiple runs of HEC-2, with subsequent runs distinguished by having twice as many computational sections. Water-surface profiles from this suite of runs are shown on Figure 2. The modeled reach for this problem is considerably longer than in the first problem. Therefore, friction is more important for this problem than the former.

With a computational reach of 10,000 feet, an error in water-surface elevation of about 2 feet is evident at the upstream end of the reach. This occurred, in part, because the modeler failed to provide enough cross sections to represent geometric and hydraulic properties of the stream reach. That is, the model "sees" the reach as a rectangular prismatic channel with a bottom width of 100 feet. This is clearly a conceptual error, and the results of this error are evident in Figure 2.

With a computational reach of 5,000 feet, the model properly preserves the geometric and hydraulic properties of the physical stream reach. But, the model contains an insufficient number of computational points to correctly compute the water-surface profile. An error of nearly 2 feet was present in the computed water-surface elevation at the upstream end of the reach. This is clearly a lack of convergence, which was corrected by including more computational sections. No additional field measurements were required. As the distance between computational sections was decreased, the water-surface profile stabilized to the shape shown. For this problem, a computational interval of 1,250 feet was adequate to provide a convergent solution.

Conclusions

One-dimensional streamflow models, including standard-step models, require a sufficient number of cross sections to satisfy two needs. First, the network must be defined with enough accuracy to enable the model to describe the hydraulics of the system. That is, a sufficient number of cross sections must be provided so that the model of each stream reach, as represented by the terminal cross sections, preserves the geometric and hydraulic properties of the prototype. These cross sections must be measured using either field surveys or photogrammetric methods. Second, a sufficient number of cross sections must be provided to allow the model to correctly estimate the solution of the governing equations in discrete space. That is, enough cross sections must be provided to force the solution computed by the model to converge to that which would be computed by an analytic solution of the governing equations, if such could be achieved. Cross sections to satisfy this second need can be provided by interpolation from those cross sections measured in the field. The number of cross sections of the first type can be known before operation of the model; they are determined by physically observable characteristics of the stream reach to be modeled. The number of cross sections of the second type can be determined only by convergence testing, that is, by adjusting the number of computational cross sections and the distance between the computational cross sections and examining the effect of such adjustments on model computations.

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Simulation of River Bed Evolution Below Tsengwen Reservoir in Taiwan

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Abstract

An uncoupled , one-dimensional river model , capable of simulating bed evolution , hydraulic sorting and armoring under unsteady flow conditions is presented in this paper. This unsteady flow over heterogenous bed model (UFOHEB) was applied to predict the variations of bed level and armor-layer grain size distribution of along the Tsengwen River downstream of Tsengwen Dam . The simulated results showed fair agreement with observed data.

Introduction

Tsengwen Reservoir is situated at the upper reach of the Tsengwen River located in the southwestern of Taiwan. The distance from dam to the river estuary is about 80 kilometers. It is necessary to study the bed degradation at downstream of the Tsengwen Dam to evaluate the safety of bridges and other structures.

Most of the grain sizes of bed material are either coaser than 30 mm close to the Tsengwen Dam or finer than 1 mm near estuary (Table 1). For this kind of erodible, heterogenous bed,several numerical models had been published [3,4,5,6,7,8] to simulate the bed evolution and the grain size distribution change of the bed material.An unsteady one -dimensional numerical model is presented here to simulate the bed degradation , armoring and hydraulic sorting phenomena downstream of dams.

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